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## Project Proposal

# Utilization of Solar Energy through Centralized Solar Farm in Bolnisi



July 2016

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### **DISCLAIMER**

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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## **Preamble**

In May 2016, a project proposal on Utilization of Solar Energy through Centralized Solar Farm in Bolnisi was prepared by an independent expert under order of Remissia Project (Agreement No ???). The list of activities implemented is as follows: analysis of existing projects in municipality of Bolnisi, selection of particular project, technical, economical and resource analysis of project activities and budgeting.

The author of the project would like to thank an Eco Engineer, an Electrical Engineer and an Economist for active involvement into working processes.

## PROJECT PREREQUISITES

### Problem Description

Since 2010 the process of undertaking voluntary commitments has been launched in Georgia under the Covenant of Mayors which means that the cities joined this initiative aim to reduce the GHG emissions from their territories by 20% till 2020. Main sectors considered by the EU cities within the frames of this initiative are transport and buildings; however, the cities may include some other sectors as well (street lighting, waste management, greening, agriculture, landscaping, etc.).

Following Tbilisi, other self-governing cities of Georgia enthusiastically embraced this initiative and started to join it gradually. 13 self-governments have already joined this initiative, including 9 self-governing cities and 4 municipalities.

There have already been developed Sustainable Energy Action Plans (SEAP) for eight self-governing cities and a monitoring report - for Tbilisi. Main sectors considered by the cities of Georgia include transport, buildings, street lighting, waste management and green spaces.

Bolnisi Municipality is an administrative unit located in central part of Kvemo Kartli region. It is bordered by Marneuli, Dmanisi and Tetritskaro municipalities and Republic of Armenia.

Area of municipality is 80 692 ha mostly represented with plain terrace with dry subtropical steppe climate, moderately cold winter and hot summer. Average annual temperature in Bolnisi is 12 °C. Average temperature of the coldest month – January is 0.3°C, while an average for the warmest month – August is 23.3°C. Annual precipitation amounts to 572 mm, maximal precipitation is observed in May (86 mm) and minimum in December (21mm).

According to the municipal board information from 2012 population of municipality is 78 700.

Bolnisi municipality has signed the Covenant of Mayors (CoM) on March 16, 2015 and thus has undertaken an obligation to prepare and implement within its administrative borders the SEAP aimed at the reduction of GHG emissions.

The SEAP for the city of Bolnisi is already prepared and includes Transportation, Buildings, Street lightning, Greening sectors as well as Agriculture.

This project addresses Buildings and Street Lightning sectors.

The municipality of Bolnisi has neither an appropriate experience, nor skills, or enough technical staff to plan or manage sustainable development process of municipality; Despite the fact the, one of strategic sectors of Bolnisi, under the short-term strategy of sustainable energy development process, is building sector in order to move smoothly to clean/low emission buildings, carrying out of serious steps and planning awareness raising activities for the population, highlighting advantages of energy savings and utilization of local renewable energy resources are necessary.

One of the projects considered in the SEAP to be implemented by Bolnisi Municipality in 2016 involves the following activities:

- EE Rehabilitation of kindergarten (PVC windows)
- Complete renovation of Kostava and Tsminda Nino streets with LED lighting
- Generation of solar power and supply to the municipal buildings and street lightening

Activities aimed at reduction of GHG emissions and energy consumption and increase in sustainability of the city infrastructure include installation of PVC windows in the kindergarten, and installation of LED lighting on 2 streets. To increase the effect of these activities and aid efforts of municipality to meet obligations after signature to the Covenant of Mayors as well as decrease of operational costs related to energy consumption it is necessary for the municipality to strengthen its project and demonstrate even more climate friendly approach and reduction of municipality's carbon footprint.

## **Project Goal**

Due to the municipalities obligations given in SEAP after signature to the Covenant of Mayors as well as a goal to decrease operational costs related to the energy consumption it is necessary for the municipality to implement a project that demonstrates climate friendly approach and reduction of municipality's carbon footprint.

To achieve this goal it is planned to establish solar energy farm that would generate electrical energy for municipal needs: supply of electricity to Kindergarten, Administration building of municipality and Bolnisi Culture house, and lighting on Kostava and Tsminda Nino streets.

Project monitoring will be conducted by Architecture and Infrastructure Development Department of Bolnisi municipality. Data will be collected on energy generation and consumption, operation service and maintenance frequency.

Information collected from the project monitoring will provide Bolnisi Municipality with significant information, statistical data and other findings to ensure long-term planning of similar activities for municipal buildings, support preparation and implementation of new projects and remove knowledge and awareness raising barriers.

Specific objectives of the project are showcasing generation of energy from renewable sources, providing energy to municipal consumer and reduction of energy consumption and GHG emissions.

To ensure the reduction of energy consumption and GHG emissions it is planned to:

- Design and install so called solar energy farm to generate solar power
- Install LED lighting (28 PCS) on the adjacent to the energy farm streets of Kostava and Tsminda Nino
- Provide solar power to energy efficient street lightning (LED). This lighting will be partially powered by energy farm during the evenings, as consumption of electricity in the municipal buildings (due to their functional purpose) is mostly observed during daytime,

- Supply solar power to municipal buildings (kindergarten, municipal administration and Bolnisi Culture House)
- Replace existing inefficient wooden windows in the building of kindergarten with energy-efficient PVC windows

## Partners and Beneficiaries

### i. Partners:

- **Bolnisi Municipality Government** – the major partner, largest beneficiary and main implementer of the project. Bolnisi Municipal government is ready to allocate funds to conduct EE measures in kindergarten building as well as installation of LED lighting on the adjacent streets;
- **Bolnisi Municipality/Community** – Community leaders will support the project in attracting qualified local staff, raising awareness and spreading obtained results for maximum use of solar energy;
- **Ministry of Environment and Natural Resources Protection of Georgia ( As a coordinator of the Covenant of Mayors in Georgia)** – the Ministry is responsible for implementing Climate Change Convention Principles throughout Georgia. Moreover, it coordinates the Covenant of Mayors initiative, supporting the participating cities and municipalities through methodologies and available data. Therefore, it may play significant role in attracting additional funding for such projects.
- **Ministry of Energy ( As a coordinator of the Covenant of Mayors in Georgia)** – the Ministry of Energy also coordinates the Covenant of Mayors initiative for the country in cooperation with the Ministry of Environment and Natural Resources Protection of Georgia. Processes, strategies or action plans of the country, scheduled by the Ministry, are directly reflected in the SEAPs of the Covenant of Mayors signatory cities and municipalities. Plans are particularly important for sustainability of heat supply and energy efficiency improvements. The Ministry actively cooperates with municipalities and cities throughout the NEEAP (National Energy Efficiency Action Plan) preparation process, supplying municipalities with parameters, preliminary evaluated at national level (GDP, Population growth, elasticity coefficients of various sectors, etc.);
- **Ministry of Regional Development and Infrastructure of Georgia** – The Ministry is directly linked to the implementation of the SEAPs and large part of activities related to the development of infrastructure and social building sector are being planned in cooperation with them as well as partially funded by them;
- **NALA (National Association of Local Authorities)** – NALA can make special contribution to local staff training initiatives. Along with additional investments, awareness

raising programs on climate change, sustainable development etc. prepared by them for municipalities are able to significantly contribute to these processes.

## ii. **Beneficiaries**

- **Bolnisi Municipal Government** – will benefit from reduced expenses and energy efficient, low emission energy and building;
- **Bolnisi Municipality/Community** – it will receive a benefit in terms of workplaces causing by spreading the innovation to other buildings, they acquire certain skills increasing their chances of employment;
- **Ministry of Environment and Natural Resources of Georgia** – as a body directly responsible for implementing the GHG emission-reduction measures across the country and developing appropriate strategies and action plans also coordinating CoM municipalities;
- **Government of Georgia** – having overall responsibility for implementation climate change convention, EU association agreement and supporting the sustainable **decentralization process through strengthening local governments**. Strong regions would be useful while fulfilling their obligations under the Climate Change Convention.

## iii. **Contributing Factors to Project Implementation**

- International obligations taken by the Country and self-governing cities on EE and GHGs mitigation (the EU Association Agreement; the Covenant of Mayors, future commitments under the Climate Change Agreement);
- Municipality's and its management's interest to implement EE and RE pilot projects;
- Availability of sufficient solar potential in this region;
- Availability of grant resources for co-financing the additional costs raised by EE measures;

## **Project Implementation Barriers**

- Procurement gaps. Procurement law is currently based only on the principle of the lowest price that has seriously damaged the quality of a number of implemented projects. This problem should be solved and the law should be improved through joint efforts of the municipalities and cooperation with the central government; a bidding document shall contain material and equipment specifications and necessity of submission certificates of origin and quality assurance to avoid delivery of low-quality products.
- Lack of awareness of local decision makers on EE and Renewable technologies. Special awareness raising and knowledge getting programmes should be organized by the project;



- Lack of relevant technical staff for preparing bidding/project document for such type of activities. On job training of local staff should be done by the project but government also have to think about outsourcing of such specific tasks;
- Insufficient budgetary resources and local staff to prepare grant application. Closer cooperation with private sector seeking support from them;
- Lack/absence of qualified construction/ESCO companies providing relevant service at Georgian market and in particular at local markets. This small project couldn't do large contribution in this direction but government should organized programmes (with the support of donors) for training of construction/ESCO firms in order to ensure the relevant market for implementation of EE measures.

## RECOMMENDATIONS ON ACTIVITIES TO BE IMPLEMENTED

Based on the study and analysis of projects of municipality and economic, social, resource related circumstances in Bolnisi municipality it is recommended to design, engineer and install a solar energy farm which consists of 20X5 m metal framed structure covered with photovoltaic panels.

Project will showcase the use of the solar energy sources for various purposes.

- The energy will be produced and stored with the following equipment
- Photovoltaic panels with total capacity of 16.6 kW (65 pieces of 255W panels with dimensions of 1640x992x40mm)
- Invertors (converting DC power generated by PV panels - into grid-synchronized AC power) 3 pieces
- Controllers (that limit the rate at which electric current is added to or drawn from electric batteries). It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk) 2 pieces

As for sufficiency of solar energy resources in project area justification is given below:

Sun: According to Technical Regulations "Building Climatology" of Georgia ([http://gov.ge/files/382\\_40062\\_363410\\_71-5.pdf](http://gov.ge/files/382_40062_363410_71-5.pdf)) direct and constant radiation in Bolnisi is following:

Constant: January – 55 kWh/m<sup>2</sup>, April – 138 kWh/m<sup>2</sup>, July – 197 kWh/m<sup>2</sup>, October - , 050598 kWh/m<sup>2</sup>

Direct: January – 32 kWh/m<sup>2</sup>, April – 68 kWh/m<sup>2</sup>, July – 128 kWh/m<sup>2</sup>, October - 58 kWh/m<sup>2</sup>

These amounts of radiation will provide sufficient energy for operation of Photovoltaics.

Establishment of energy farm will result in generation of electric power estimated at 9196kWh (16.575kWx8hX365daysX19%) where 16.575kW is total capacity of photovoltaic system, 8h is daily

operation time, 365 days is annual amount of days in operation and 19% is efficiency rate of Photovoltaic system used to calculate working capacity of total capacity.

## **EXPENDITURE ESTIMATES FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY MEASURES**

Major cost of the project is covered by Bolnisi Municipality to finance the following tasks:

- Rehabilitation of Kindergarten building (840 sq. m.)
- Renovation of Kostava and Tsminda Nino streets
- Connection of Energy farm to consumers (street lighting, municipal buildings)

Expected budget for activities assigned by Bolnisi Municipality in the boundaries of project amount to GEL 930,000. Assuming exchange rate of GEL 2.15 to 1 USD the budget equals to USD 432,558.

EE and RE Measures to be implemented by project include:

- Installation of so called solar farm including its infrastructure (20x5 m metal frame structure, inverters and controllers, fixings, cables etc).
- Presentation, discussion and approval of project details (design, solutions, work-plan) with stakeholders (municipality authorities, grant provider) and interested parties
- Execution of equipment purchase, production and assembly of components and installation works
- Monitoring and control of execution of works up to date of completion
- Providing training of local human resource allocated by municipality on maintenance and operation of the equipment installed in the boundaries of the project.

Handing over executed works to Bolnisi Municipality: project monitoring of installed equipment will be conducted by Architecture and Infrastructure Development Department of Bolnisi municipality. Data will be collected on energy generation and consumption, operation service and maintenance frequency. Service of operation and maintenance of the equipment will be included in the procurement tender and therefore will be conducted by the company that wins the tender for the period of 1 year. After this period municipality will announce a new tender for the aforementioned services and cover the costs of hiring the winning company.

Total cost of the above is estimated at USD 50,000.

Project considers the following budget items:

## I. Project Management:

Project management that involves design of energy farm; Mechanical, Electrical and Plumbing engineering of infrastructure; mechanical design and engineering of infrastructural solutions; managing the implementation of the project, financial and economic aspects and coordination of tasks with different parties and successful and smooth implementation of all tasks of project, timely fulfillment of the project and supervision of implementation throughout the timeframe will be accomplished by the team of Project Director, Project Manager, Architect, MEP Engineer and Mechanical Engineer.

Total project management costs are USD 8700.

## II. Travel and Per Diem

A. Travel of project staff will be required for site visits for pre-installation phase, meetings with municipality representatives, supervision, etc. Total number of visits 25 (2-4 managers per visit). Cost per visit \$30. Total travel costs - \$750.

## III. Procurement

**A. Execution** of equipment purchase, construction, production and assembly of components and installation works.

Total budget – \$40,035

## IV. Other Direct Costs

**A. Office/Communication expenses** - will cover costs of office supplies needed to complete the project such as printer paper cartridge, telephone bills, bid announcements etc.

Price/month- \$172 Total (3 months) - \$515

#	Item	Unit	Quantity	Unit Price (usd) incl. installation (USD)	Total Price incl. installation (USD)
1	Energy Farm (Photovoltaic panels, inverters, controllers, structure, foundation and metal framework, fixing and cables)	Set	1	40 035	40 035
2	Project Management (including salaries, per diem and other direct costs)			9 965	9 965
	Total				50 000

## SUSTAINABILITY, ENVIRONMENTAL AND ECONOMIC ANALYSIS

The sustainability of the project is a direct outcome of obligations of municipality's joining to the Covenant of Mayors. Another important factor that backs the project fulfillment and guarantees its growth beyond the phase is reduction of operation costs due to reduced consumption and therefore economy of the budget for municipal utility bills. Therefore it is in the municipal authority's interest to sustain project and take on maintenance and operation of the project after it is handed-over.

In addition to achieve high level of sustainability New Technology Center will provide training of local human resource allocated by municipal authority on maintenance and operation of the equipment installed in the boundaries of the project.

It is also important to note that sustainability is aided by Georgia-EU association agreement, which included Georgia's responsibility to adapt the environmentally friendly and energy efficient technologies.

As for the replicability of the project its' feasibility is based on the demonstrational qualities of the project. Use of solar energy in the region makes it possible to replicate these technologies and approaches not only in municipal buildings like kindergartens and administrative units but a number of other municipal, state and residential buildings.

As for GHG's reduction and energy savings these will be obtained from installation of PVC Plastic windows that will provide reduction of building consumption on heating from 150 W/sq.m. to 100 W/sq.m. As a result this will decrease energy consumption on heating by 51,340 kWh ( $840\text{sq.m.} \times (0.15 - 0.1) \times 8 \times 151^1$ ). To acquire the mentioned above amount of energy (51,340 kWh/yr) by burning the natural gas, it's demanded volume will be  $51,340 / 9.72 = 5,282 \text{ m}^3$  costing  $5,282 \times 0.84 = 4,437 \text{ GEL}$ .

This reduction is providing in decrease of 10.4 tons/annually GHG emissions (0.202kg/kWh).

Replacing street lighting with LED will provide further economy and reduction of GHG emissions. This activity will result in the following reduction:

	Amount of lamps	Capacity (W)	Daily operation hours	Daily consumption in kWh	Annual consumption in kWh	Emission factor kg CO2/kWh
Base Lighting	28	250	12	84	30 660	0.104
After installation of LED lighting	28	70	12	23.52	8 585	0.104

Annual reduction of consumption – 22075 kWh,

<sup>1</sup> where 840 sq. m. is heated area of kindergarten building, 0.15 kW/sq.m is consumption on heating before windows renovation, 0.1 kW/sq.m is consumption on heating after windows renovation, 8 is daily duration of heating operation in hours and 151 is length heating season per year in days.

Annual reduction of GHG emissions – 2.3 t

Thus total reduction of GHG emissions from activities already planned by municipality are estimated at 12.7 tons.

Grant funded activities will provide additional reductions is obtained from electricity generation from solar energy. Annual production of electric power is estimated at 9196 kWh which with a conversion rate of 0.104 t CO<sub>2</sub>/MWh amounts to 0.96 tons/year.

Total emission reduction from all project activities is 13.66 tons per year.

Total emission reduction from all project activities is based on life-time of each activity and is as follows:

#	Activity	Annual Saving in kWh	Lifetime (years in operation)	Total savings in kWh	Emission Factor kg per kWh	Total emission reduction in Tons
1	Windows' Renovation	51.340	8	410.720	0.202	82.97
2	LED lighting installation	22 075	15	331,128	0.104	34.44
3	Energy Farm establishment	9 196	20	183,920	0.104	19.13
	Total					136.53

## Monitoring and Evaluation

Project monitoring and evaluation will be conducted by representative of Architecture and Infrastructure Development Department of Bolnisi municipality. Major source of data collection on energy generation and consumption will be accomplished through software tools that are incorporated into the inverters of the energy farm. Each inverter installed in a PV plant is accessible through Bluetooth® and Speedwire/ Webconnecttechnology as standard. Comprehensive calculations for all essential technical criteria in a photovoltaic system help optimize configuration. Integrated tool tips explain the calculated values and indicate when values have not yet reached the optimal range. This prevents bad planning that would consequently be a lot of hassle to correct in the actual system.

Project data regarding the configured photovoltaic system is all compiled into a detailed overview at the end. This overview can be saved as a PDF and sent by e-mail. The data format XML allows project data to be exchanged easily with other PV planners and applications.

In addition to the above collected data (energy generation and consumption overview with detailed information generated kWh, and distribution among consumers – Kindergarten, Administration building, Culture house and LED lighting) annual sum of utility bills on electricity one year after the launch of the project will be compared to baseline consumption of 4 consumers (savings are determined by measuring energy use at the utility meter level):

Electricity:

1. Kindergarten – with annual electricity consumption of 6,105 kWh in 2015
2. Administration building – with annual electricity consumption of 172,529 kWh in 2015
3. Culture house - with annual electricity consumption of 59,633 kWh in 2015
4. LED lighting – projected baseline consumption of 30,660kWh per/y.

Heating:

1. Kindergarten – with annual consumption for heating of 152,208 kWh/y.

This type of verification compared to data from inverter may not be as accurate due to possibility of increased or decreased consumption independent from generation (ex. Hotter or cooler weather that results in change of cooling or heating demand, increase or decrease of inhabitants, visitors or other beneficiaries of buildings, etc).